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ILLUMINATION OF CANNON TUBE BORE SURFACES FOR VISUAL INSPECTION

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US ARMY ARMAMENT COMMAND

PRODUCT ASSURANCE DIRECTORATE
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To control light loss in fiber connectors it was found that the centerline of one fiber core should be aligned with the centerline of the other core. The means of obtaining this alignment and the transmission efficiency of light must be coordinated with the manufacturing efficiencies in order to obtain a practical connector design.

MATERIALS TESTING TECHNOLOGY PROGRAM (AMS 4931)

Report No.: WVT-QA-8001

Title: Illumination of Cannon Tube Bore Surfaces for Visual Inspection

THIS PROJECT HAS BEEN ACCOMPLISHED AS PART OF THE US ARMY MATERIALS TESTING TECHNOLOGY PROGRAM, WHICH HAS FOR ITS OBJECTIVE THE TIMELY ESTABLISHMENT OF TESTING TECHNIQUES, PROCEDURES OR PROTOTYPE EQUIPMENT (IN MECHANICAL, CHEMICAL, OR NONDESTRUCTIVE TESTING) TO INSURE EFFICIENT INSPECTION METHODS FOR MATERIEL/MATERIAL PROCURED OR MAINTAINED BY AMC.

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ABSTRACT

To control light loss in fiber connectors it was found that the centerline of one fiber core should be aligned with the centerline of the other fiber core. The means of obtaining this alignment and the transmission efficiency of light must be coordinated with the manufacturing efficiencies in order to obtain a practical connector design.

1. PROBLEM STATEMENT

Existing borescopes for viewing cannon bores utilize illuminating heads with incandescent or fluorescent lamps. There is a safety hazard associated with high intensity incandescent bulb and electrical wiring e.g., heat and electrical shock. A new method is required using illuminators for use with fiber optic light guides to provide a convenient, safe and inexpensive source of intense illumination.

2. BACKGROUND

Several firms are now engaged in the manufacture and sale of fiber optic materials and devices including: American Optical Company, American Cystoscope Makers Inc., Bausch and Lomb Inc., Valtec Corp and Optics Technology Inc. Light guides are used in many applications where there is a need to carry light from one point to another. Industry uses the light devices to examine the interior surfaces of pipes, tubing, checking malfunction in gage valves and inspecting the inner surface of various containers.

Therefore, it was considered desirable to determine if a relative simple method could be devised to couple the fiber optic light guides to the illuminators and an outside light source which will transmit cold light and be capable of supplying multiple levels of illumination from a white light source.

3. APPROACH

Investigate the various suppliers of fiber optics for optimum type of fiber (plastic-glass) to provide for the lowest possible loss in light transmission. Since loss characteristics are directly related to accurate alignment of the fiber, particular design consideration was given to three critical areas:

1. Lateral Displacement
2. Angular Displacement
3. End Separation

Design of equipment to incorporate low light loss can be attained by using a floating alignment bushing made of polymeric material and a spring retainer device in each channel which maintains the required separation, absorbs connector contact channel tolerance compensated. The performance of any one given channel is therefore independent of the tolerance build-up of any other channel. Figures 1, 2, 3 and 4 dipict the design configuration that would be followed to produce a prototype fiber optic borescope. The incorporation of light conducting fiber in lieu of electrical wiring in the borescope will remove the risk of electrical shock to the operator. The use of fiber optics allow the hot external light source to be shielded and cooled without the constraints associated with the hot incandescent lamps.

4. EQUIPMENT USED

The equipment used for the investigation was limited to the illuminators and fiber light pipes on hand. Aquisition of major items was curtailed by the re-routing of funds from this project to the (MRB) Magnetic Recording Borescope project being administered by (APG) Aberdeen Proving Ground.

5. SYSTEM FUNCTION

The system is designed and engineered for use with high intensity illuminators. The illuminator is a compact device which features a fiber optic light pipe adaptor for quick disconnect conversions, quick twist knob for easy access to lamp replacement, on/off toggle switch, cooling fan and variable light rheostat.

The light transmitted from the illuminator through the light pipes is coupled to a mating adaptor on the annulus ring light. Light is concentrated accurately upon the proximal glass fiber bundles which are contained in the borescope tubular section. Provision is made in the illuminator to vary lamp voltage which is deemed necessary to vary intensity of light to obtain optimum illumination for viewing various cannon tube bores.

Intense cold light is provided where it is needed the most and that is where the mirror is located at the objective end of the borescope. The highly flexible fiber optic branches (tubes) can be directed to provide near shadowless illumination at the desired point of view.

6. TEST RESULTS AND EVALUATION

The testing and evaluation of the fiber optic illuminating system consisted mainly of experimenting with on-hand equipment. Considerable time and effort was spent in determining light losses in single fiber terminations. Accordingly, the experimental phase of this project was limited to providing even illumination through a seven foot long borescope.

Evaluation of the illumination system shows that while good, permanent end splices of fiber connectors are available, separable connectors are hard to find. To control as much loss as possible in the connector, the following designs are being considered:

a. Double Eccentric Connector, (figure 5). By rotating the different eccentric sections of the connector the fiber cores axes can be brought into very close alignment, thus it can be concluded that lowest possible losses can be obtained.

b. Tapered Plug Connector, (figure 6). This connector design uses an index matching material to eliminate fiber interface losses. The axial concentricity tolerance build-up includes the path from core to fiber cladding, cladding to plug taper, plug alignment taper to biconical sleeve taper, alignment of the biconical taper themselves, and back down again to the other fiber core axis. Any rotation of the parts must show minimal excursion of the fiber central axis.

7. CONCLUSIONS

This limited investigation has shown that no matter what the fiber size or type, all approaches to separable connectors for fiber optics have the same type of problems. The centerline of one fiber core should be aligned with the centerline of the other fiber core. Every connector design has as its objective the axis alignment with the highest degree of accuracy possible. The means of obtaining this alignment and the transmission efficiency of light must be coordinated with the manufacturing method efficiencies in order to obtain a practical connector design.

8. RECOMMENDATIONS

Based on the results of this limited investigation, it is recommended that an optical self-centering, overlap style connector be designed to hold within reasonable levels, the coupling losses attributed to fiber core diameter variation, core axial displacement, and angular misalignment without the need for special or difficult to control manufacturing or assembly methods. It is also recommended that the fiber optic illumination system be limited to a seven foot borescope length which can be used to visually inspect the cannon tubes bores of the following weapons; 60MM, 81MM, 4.2 inch mortar system, 90MM, 106MM recoilless rifle systems and chamber and origin of rifling of all cannon tubes.

Performance evaluation of the illuminating system is favorable for continued development efforts. It is recommended that studies and work be continued on design refinement and the preparation of product engineering drawing for the acquisition of illuminating fiber optic systems.

OBJECTIVE TUBE ASSY

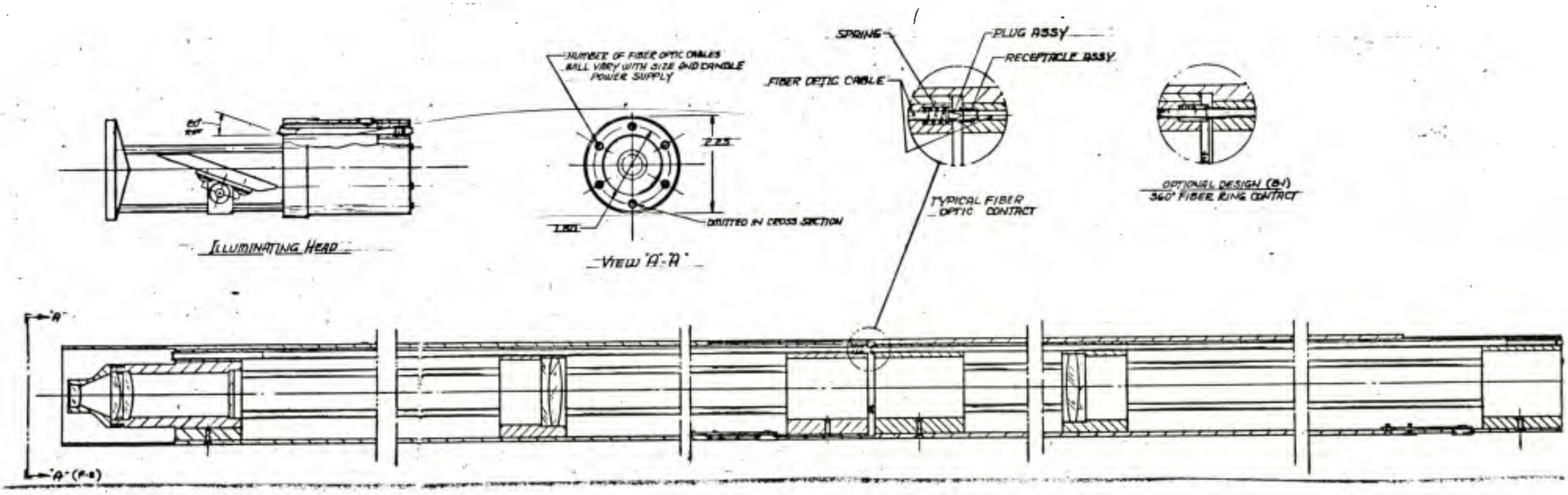


FIGURE - 1

ADAPTOR TUBE ASSEMBLY

COMPLETE BORESCOPE CONSIST OF-ADAPTER TUBE,
3 EXTENSION TUBES AND OBJECTIVE TUBE
TOTAL LENGHT=(26.3) WITH 9 CONTACTS

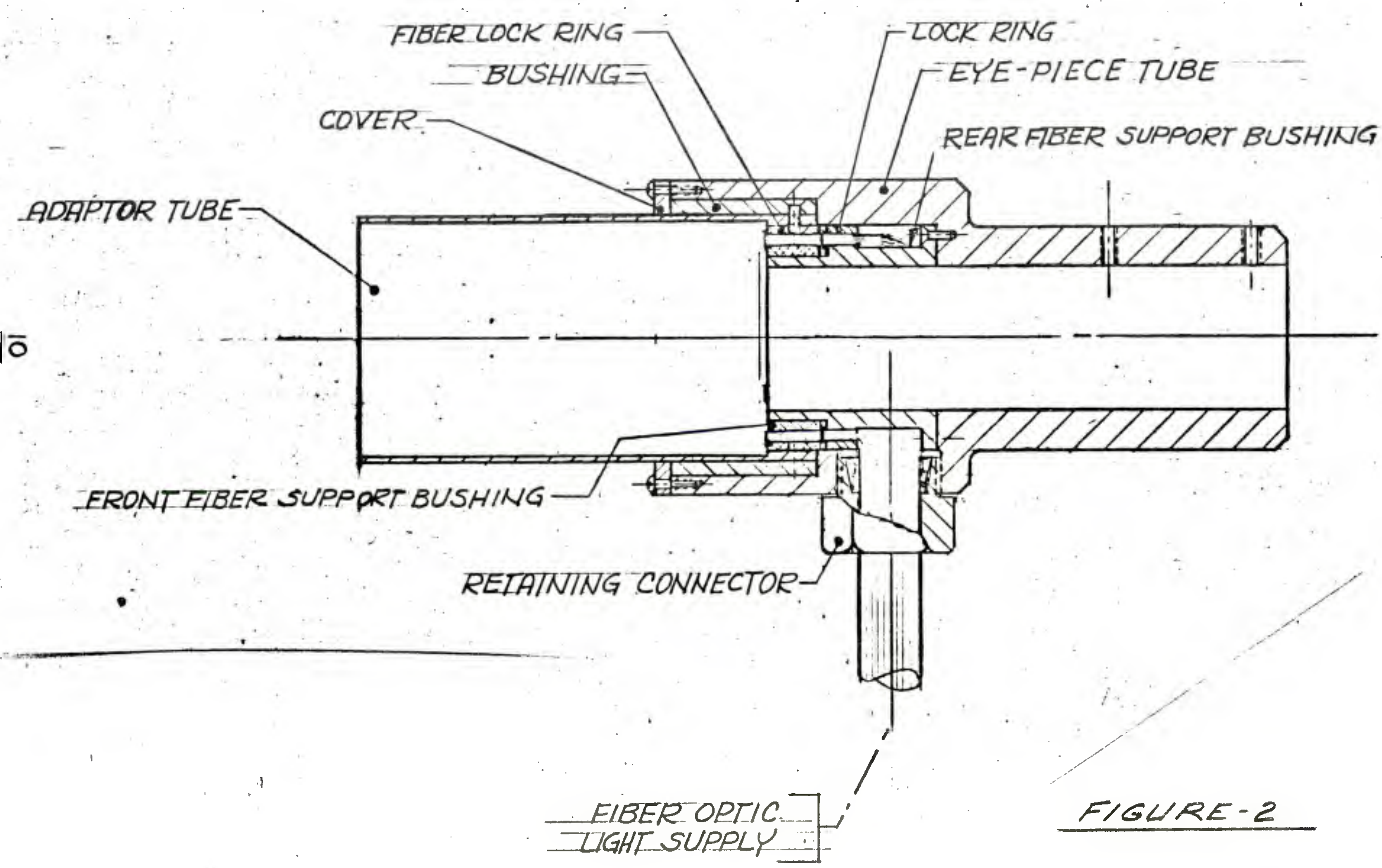


FIGURE-2

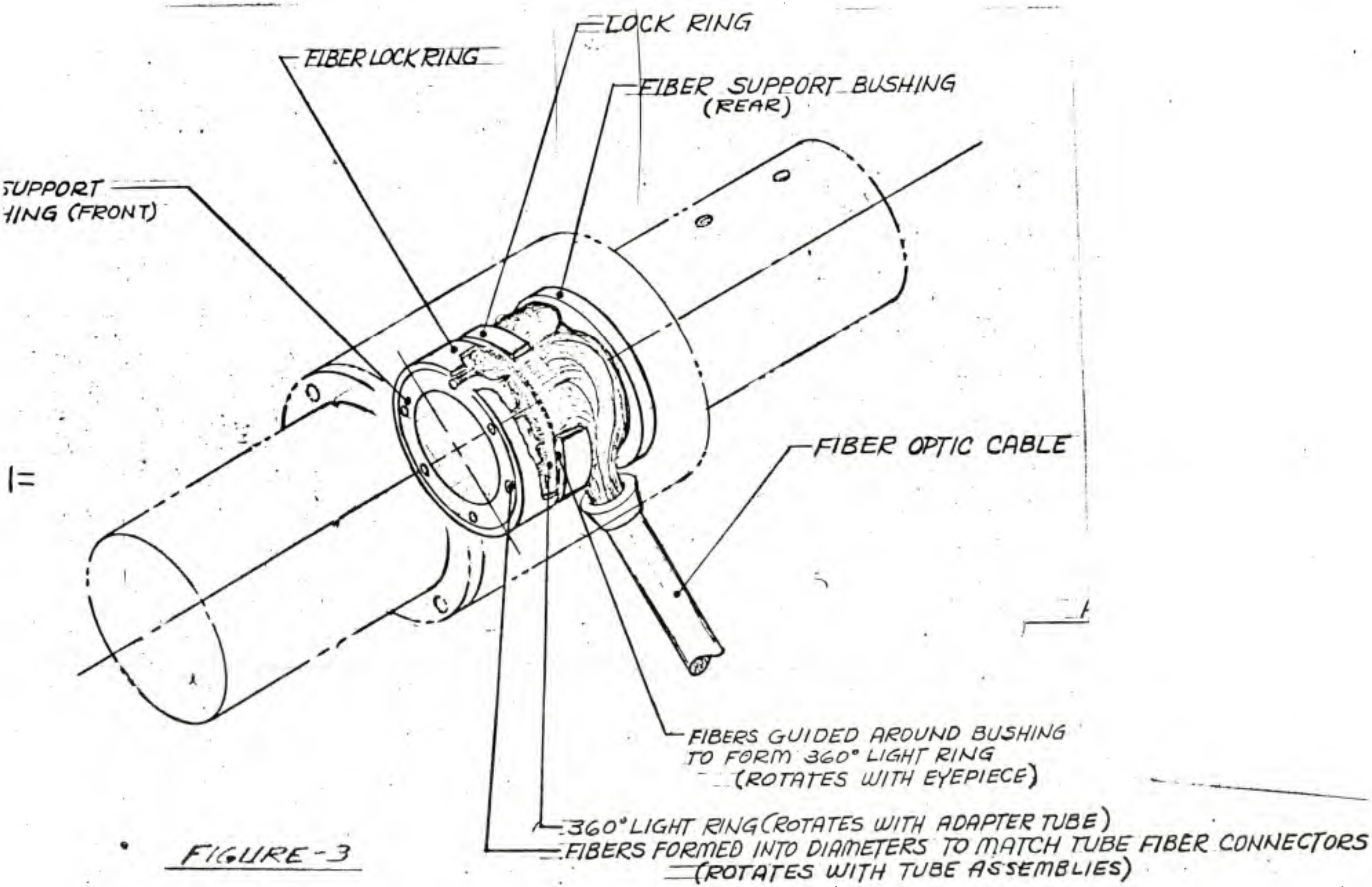

LOCK RING
FIBER LOCK RING
FIBER SUPPORT BUSHING (REAR)
SUPPORT
HING (FRONT)
FIBER OPTIC CABLE
FIBERS GUIDED AROUND BUSHING TO FORM 360° LIGHT RING (ROTATES WITH EYEPIECE)
360° LIGHT RING (ROTATES WITH ADAPTER TUBE)
FIBERS FORMED INTO DIAMETERS TO MATCH TUBE FIBER CONNECTORS (ROTATES WITH TUBE ASSEMBLIES)

FIGURE-3

11

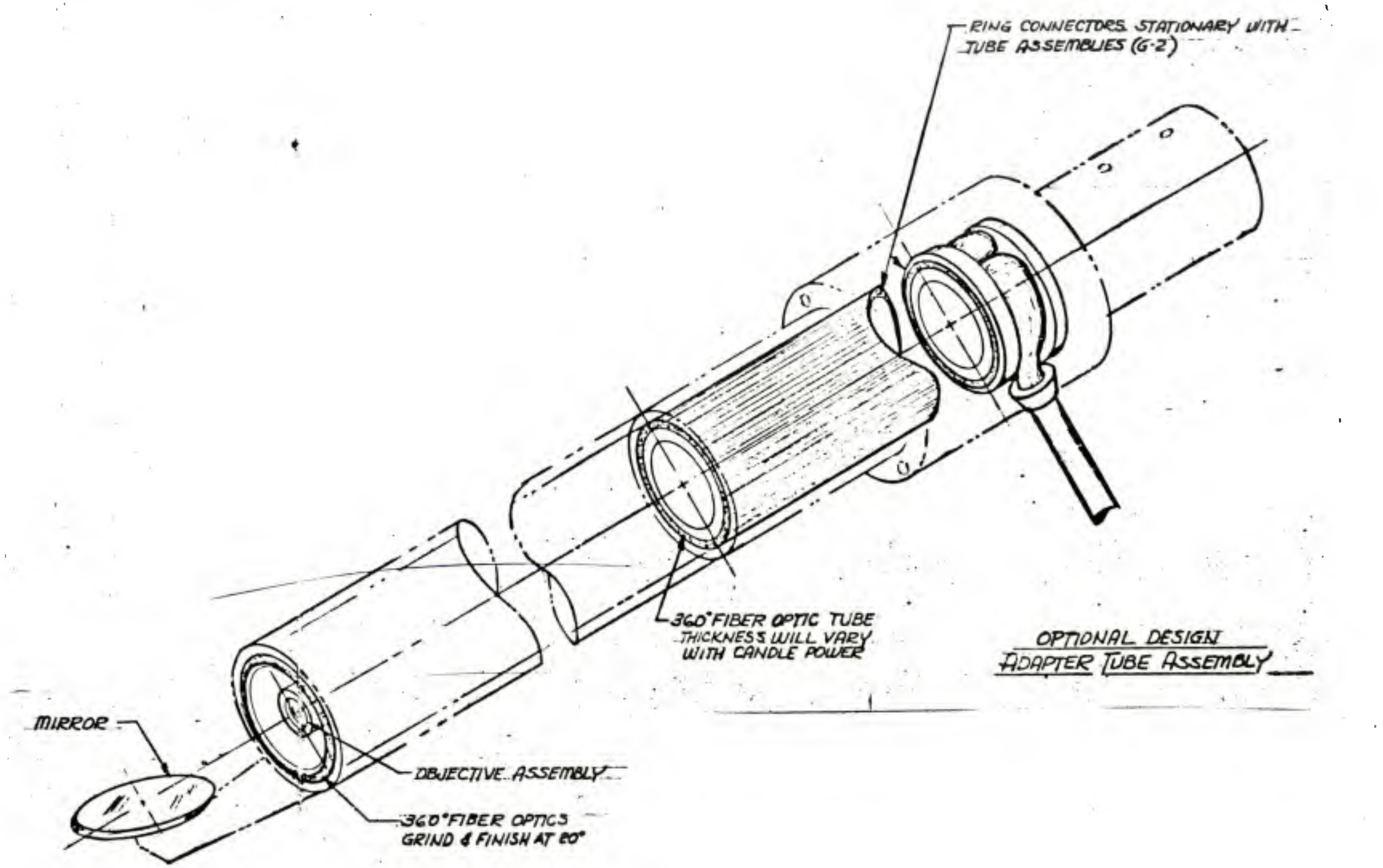
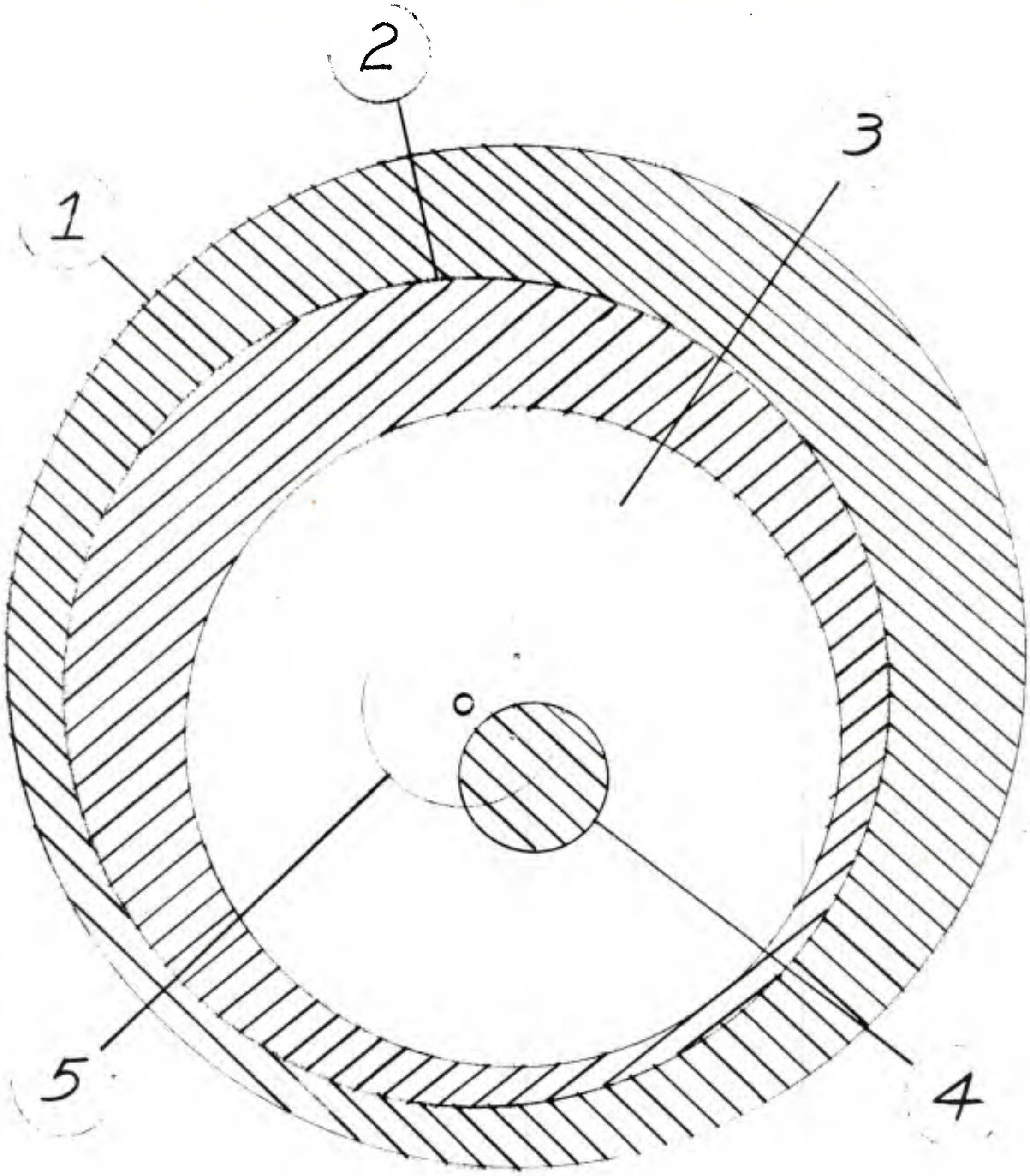

RING CONNECTORS STATIONARY WITH TUBE ASSEMBLIES (G-2)
360° FIBER OPTIC TUBE THICKNESS WILL VARY WITH CANDLE POWER
OPTIONAL DESIGN
ADAPTER TUBE ASSEMBLY
MIRROR
OBJECTIVE ASSEMBLY
360° FIBER OPTICS GRIND & FINISH AT 20°

FIGURE - 4

DOUBLE ECCENTRIC CONNECTOR



1. OUTER ECCENTRIC TUBE 2. INTERMEDIATE ECCENTRIC TUBE 3. INNER TUBE 4. OPTICAL FIBRE CORE 5. MOVABLE CORE CENTER AREA.

FIGURE - 5

TWO TAPERED PLUGS ALIGNED BY A BICONICAL SLEEVE

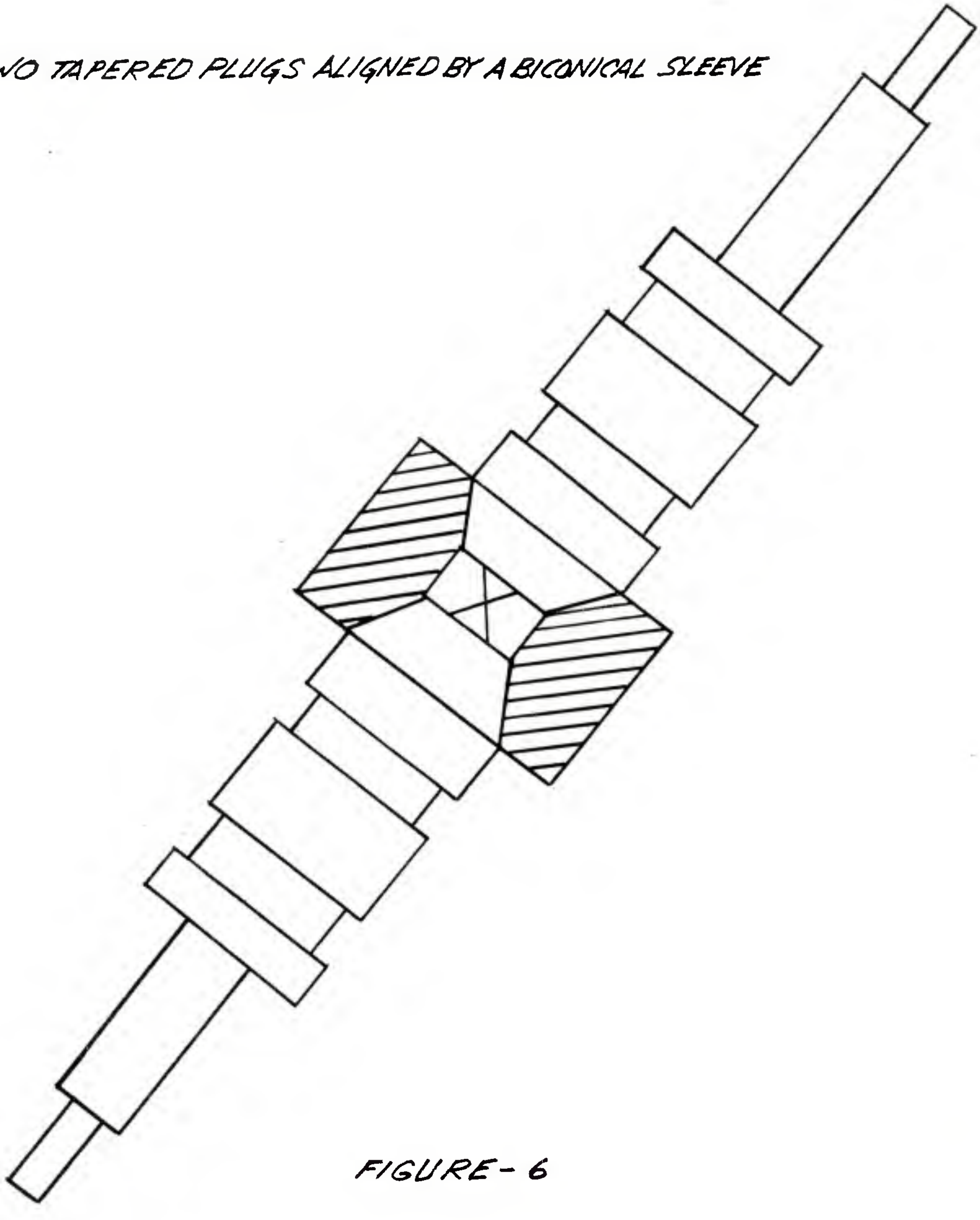


FIGURE - 6

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